

POLYVINYL ALCOHOL (PVA) / CELLULOSE ACETATE (CA) BASED ENVIRONMENTALLY FRIENDLY HYBRID FILTER PRODUCTION

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Abstract: *In this study, the development of filters made of spunbond fabric coated with nanofiber surface was studied. With Covid 19, filters have gained importance in terms of human health. In this study, it is aimed to produce filters by using cellulose acetate and polyvinyl alcohol materials with the help of solution blowing method. The purpose of choosing polyvinyl alcohol (PVA) raw material is that it is not toxic and not polluting the environment, has high chemical stability, high abrasion resistance and low cost.*

Cellulose acetate (CA) material was chosen because it is a renewable, biodegradable, low-cost and high-quality fiber source that can be used in many manufacturing processes. These two materials were chosen in order to make the produced filter environmentally friendly and biodegradable. For the samples produced; tensile strength and FT-IR tests were carried out.

Keywords: *Hybrid Filter, Cellulose acetate (CA), Polyvinyl alcohol (PVA), Nanofiltration, Solution Blowing Method*

1. INTRODUCTION

As a result of the rapid increase in industrialization and urbanization, especially air pollution increases with the pollution of natural resources. This pollution is caused by macro and micro particles in the air. These particles, which can be in solid and liquid phase, enter the human body through the air and cause various respiratory diseases. In order to be protected from the effects of living things such as bacteria, which are harmful to human health and are about 100 nm in size, the air must be filtered effectively. It is aimed to reduce the number of material layers used in the filters and to provide better filter performance through the lower fiber diameter and porosity, by adding a low-thickness nanofiber layer that will perform the same or better than the filter materials obtained from traditional nonwoven surfaces. Since the costs of filters with high particle holding capacity are high, low-cost hybrid filter production is aimed in this project. (Graham K.)

In this study, nano surface coating was applied on the nonwoven surface to increase the filtration amount. The main thing in filtering is the size of the pores in the material. There are two methods for reducing the pore size. These;

Obtaining a more voluminous surface by increasing the number of fiber layers,

It is the production of low diameter fibers with the number of layers and a low volume/thickness structure.

Depending on the size of these pores, the efficiency of the filter class and production standards change. It is aimed to make more precision filtering by using nano surface. In this work, the straining effect, one of the filtering methods, was used. (Gundogdu, N. A. S.)

In air filtration, submicron size fibers provide higher filter efficiency at the same pressure drop compared to others. Although the pressure drops increases, the higher diffusion, interception and

inertial effects of nanofibers will increase more than the pressure drop, so this will positively affect the filter performance. (Kosmider and Scott)

2. MATERIALS AND METHODS

2.1. Preparation of PVA and CA solutions for the air blow method

The solution was prepared in 2 steps. In the first step, PVA and CA were dissolved separately. 9% (w/v) PVA and 9% (w/v) CA solutions were prepared separately in a mixture of AA and distilled H₂O at 80°C for 3 hours. In the second step, the dissolved PVA and CA solutions were combined at 80/20, 65/35 (v/v) ratios and mixed for 1 hour at 80°C. After 1 hour, it was stirred for 30 minutes at room temperature. (Felgueiras H.P.)

Mixture of soluble PVA and CA was produced in a solution blowing machine at a rotation speed of 100 RPM, a flow rate of 2mL/hour, a constant pressure of 2.5 bar, using air at a constant pressure of 2.5 bar, at 30 cm between the collector needle tip, at a temperature of 23-25°C, in an environment of 34-46% relative humidity. The viscosity values of the solutions produced are given in the table below.

Table 1. Viscosity Value

Viscosity was measured with a 100 RPM S21 spindle.		
	cP Value	% Value
%100 PVA	198.0	%39.6
%80 PVA / %20 CA	184.0	%36.8
%65 PVA / %35 CA	186.5	%37.3

2.2. Physical Properties

Tensile strength test was carried out with Instron 4411 brand universal test device according to TS EN 20-9073-3 standard. The tests were carried out by cutting the nonwoven textile surface structure in 20x5cm (length x width) dimensions and setting the piston speed to 100mm/min. The results are read in MPa (megapascal).

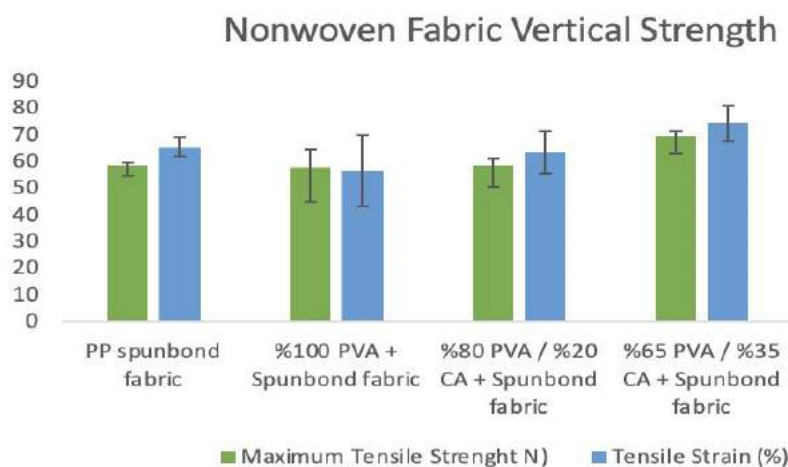


Figure 1. Vertical Strength Graph

According to the graphic given above, when the effect of nano-surfaces obtained with productions made in 5 minutes on spunbond fabric tensile strength was analyzed, it was determined that 65% PVA

/ 35% CA ratios increased the tensile strength by 19%. It has been determined that 100% PVA added and 80% PVA / 20% CA coated fabrics have similar strength values with the nano surface uncoated spunbond fabric. The flexibility of the filter structure increased with the increase of the CA ratio.

3. RESULTS AND DISCUSSION

Air permeability test was made out with SDL Atlas M021S test device according to TS 391 EN ISO 9237 (Determination of permeability of fabrics to air) standards. Testing area was 5cm², air pressure 50 Pa and 100 Pa (Pascal). Results are read in L/min (Liter/minute). (Dincer K.)

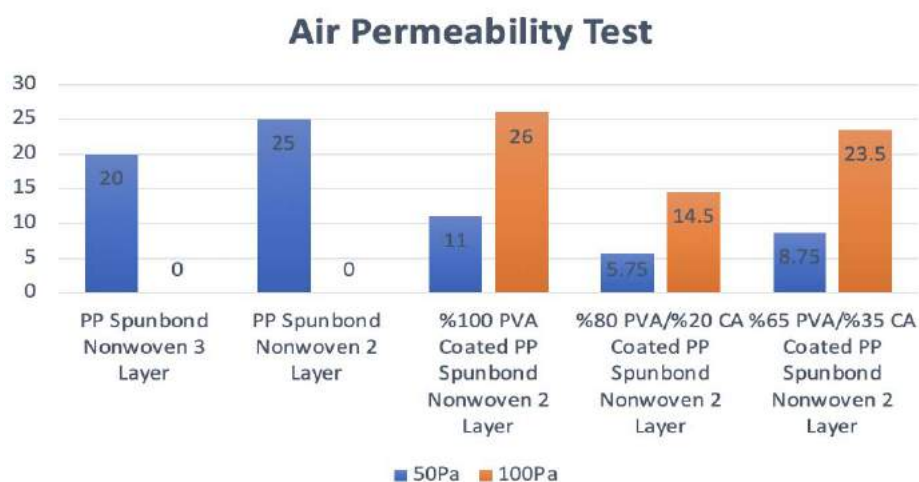


Figure 2. Air Permeability Test

In the air permeability test, the results of two and three layers of raw spunbond fabric were compared with nano surface coated fabrics. Considering the test results, no results were obtained for uncoated fabrics under 100 Pa air pressure. (Akıncı F.C.)

Under 50 Pa air pressure, air permeability decreases by 50% when nano-coated fabrics and raw fabrics are compared. The lowest air permeability value was measured at 5.75 L/min under 50 Pa pressure of the spunbond fabric coated with 80% PVA 20% CA.

It was determined that the fabrics coated with nano surface decreases the air permeability.

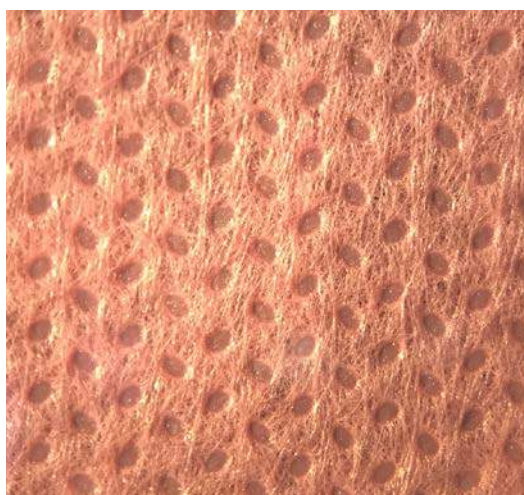


Figure 3. Non coated PP spunbond fabric

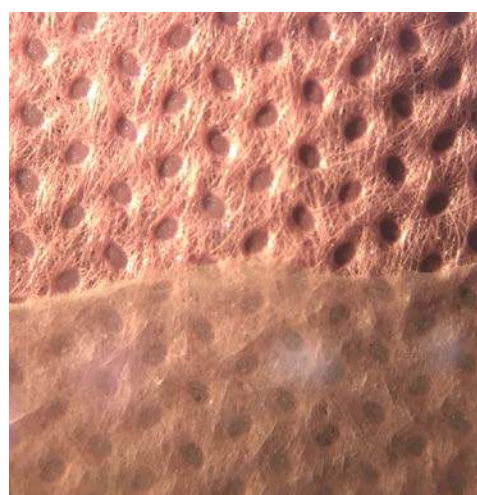


Figure 4. % 100 PVA coated spunbond fabric

Nano-coated and uncoated nonwoven fabrics can be seen at 60x magnification under the fabric microscope. For Figure 4.-5.-6., the upper area is uncoated, the lower area is the nano-surfaced.

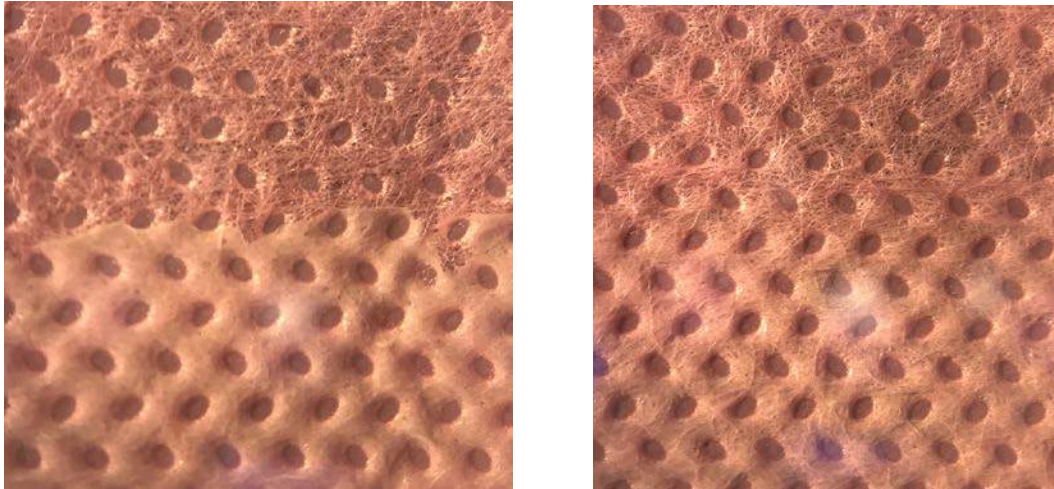


Figure 5. %80PVA /%20CA coated spunbond fabric **Figure 6.** %65PVA /%35CA coated spunbond fabric

There are specific peaks (Figure 7) for CA at 1735cm^{-1} (C=O), 1375 cm^{-1} (C-CH₃) and 1254cm^{-1} (C-O-C). (Zeeshan Khatri) For CA, the peaks at 1735cm^{-1} (C=O), 1254cm^{-1} (C-O-C) peaks in 65% PVA/35% CA sample, in FTIR measurements, these peaks were stronger than 80% PVA/ 20% CA mixture. Also, it was determined that these peaks were not detected in the 100% PVA sample. (Song J.)

The characteristic peaks for PVA are 2900cm^{-1} (C-CH₂), 1450cm^{-1} (-OH), 1375cm^{-1} (C-CH₃). The vibrational band observed between 2840 and 3000 cm^{-1} refers to the stretching C-H from alkyl groups and the peaks between 1750 – 1735 cm^{-1} are due to the stretching C-O and C=O from acetate group remaining from PVA. (Mansur H. S.)

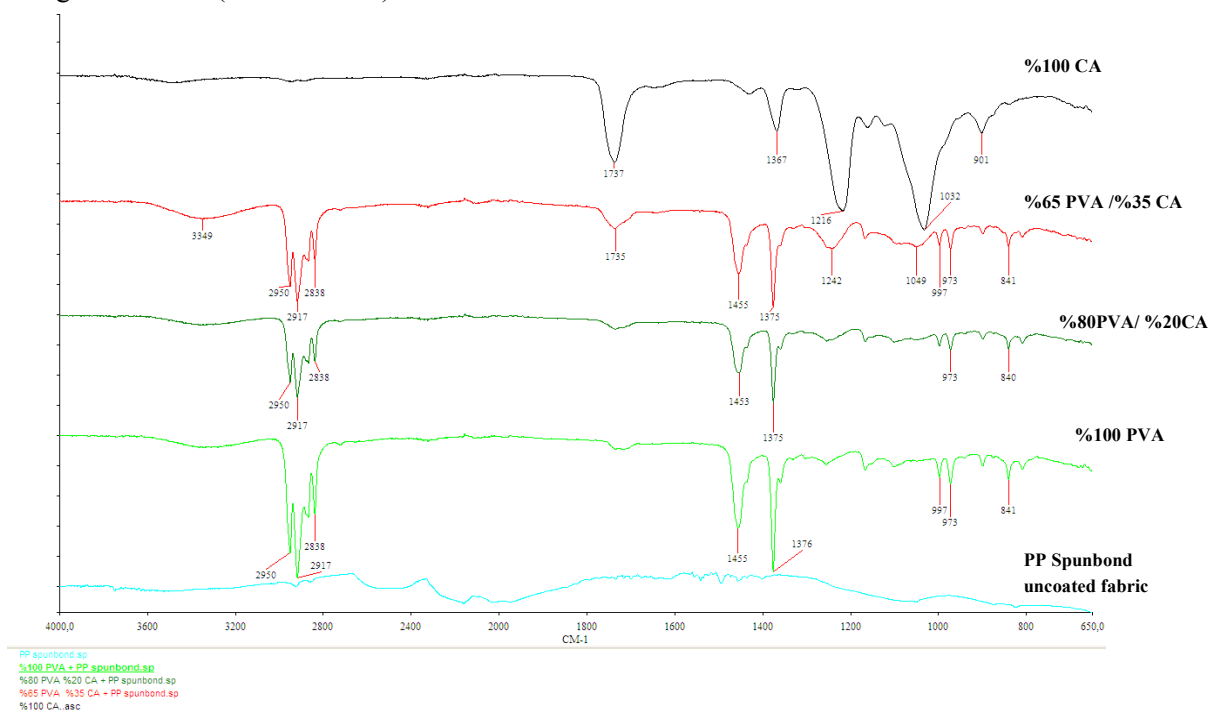


Figure 7. FT-IR Spectra

4. CONCLUSION

In This study includes preliminary results of studies on improving the performance of spunbond fabrics used for filter purposes with nanofiber surface. PVA stands out with its low cost and biodegradable material, while CA was chosen for its properties such as flexibility, hardness, tensile strength, and its resistance to bacteria. As a result of the selection of these materials, nano fiber production was made by solution blowing. In the later stages of the study, the filter class of the produced filter will be determined by measuring the filtration degree with the TS EN 1822-1 test and SEM (scanning electron microscope). According to the tensile strength test result, it is expected that the air flow resistance will be high because the fabric coated with 65% PVA/35% CA solution increases its tensile strength by 19%.

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REFERENCES

- Gündoğdu, N. A. S., (2016) Aerosol filtration performance of nanofibrous webs produced via centrifugal spinning technique, ITU institute of science master thesis.
- Felgueiras H. P., Teixeira M. A. , M., Tavares T. D., Amorim T. P. , (2019) New method to produce poly(vinyl alcohol)/cellulose acetate films with improved antibacterial action, Elsevier.
- Graham, K., Ouyang, M., Raether, M., Grafe, T., McDonald, B., Knauf, P., (2002), Polymeric nanofibers in air filtration application, *15. Annual Technical Conference&Expo of the American Filtration & Separations Society*, Galveston, Texas, USA, 17p.
- Zeeshan Khatri, Kai Wei, Byoung-Suhk Kim, Ick-Soo Kim, (2011) Effect of deacetylation on wicking behavior of co-electrospun cellulose acetate/polyvinyl alcohol nanofibers blend, Elsevier.
- Mansur H. S., Sadahira C. M., Souza A. N., Mansur A.A.P., (2008) FTIR spectroscopy characterization of poly (vinyl alcohol) hydrogel with different hydrolysis degree and chemically crosslinked with glutaraldehyde, *Materials Science and Engineering C* 28 (2008) 539–548 Elsevier.
- Song J., Birbach N. L., Hiestroza J. P., (2012) Deposition of silver nanoparticles on cellulosic fibers via stabilization of carboxymethyl groups, *Cellulose* 19:411–424 Springer.
- Kosmider, K., Scott, J., (2002), Polymeric nanofibers exhibit an enhanced air filtration performance, *Filtration and Separation*, doi:10.1016/s0015-1882(02)80187-2
- Dincer K, .Önal G., Selbes B., Akdemir A.(2018), Nanofiber Tabakalı Hava Filtrelerinin Partikül Yakalama Performanslarının İncelenmesi, *Journal of Natural and Applied Sciences* Volume 22, Special Issue, 32-41, doi:10.19113/.sdufbed.45779
- Akıncı F.C., Kaynak H.K., Korkmaz Y.(2018): Filament İnceliği ve Atkı Sıklığının Mikrofilament Dokuma Kumaşlarda Geçirgenlik Özelliklerine Etkileri, *Tekstil ve Mühendis*, 25: 111, 234-240.